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(54) **Rubber composition for tyre tread.**

(57) A tread rubber composition is provided which includes 100 parts by weight of a diene rubber containing as a main component thereof at least one rubber selected from the group consisting of natural rubber, polyisoprene and polybutadiene, and 30 to 90 parts by weight of a vulcanised rubber powder, wherein the vulcanised rubber powder is a powder of a rubber resulting from vulcanisation of a rubber composition including 100 parts by weight of a diene rubber containing as a main component thereof at least one rubber selected from the group consisting of natural rubber, polyisoprene and polybutadiene, and 30 to 100 parts by weight of a clay mainly composed of kaolinite. The rubber composition for tyre tread assures improved braking performance with the fracture resistance thereof kept satisfactory and, hence, a tyre tread made of such rubber composition makes it possible to build a studless tyre exhibiting an improved gripping force.

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The present invention relates to a rubber composition for a tyre tread to be used for improving the gripping force of a studless tyre, to a tyre tread formed from such a rubber composition, and to a tyre having such a tyre tread.

5 The predominant factors responsible for friction between a tread rubber and a road surface include (1) hysteresis loss friction, (2) adhesion friction and (3) dig-out friction. When on a road surface of an extremely low friction coefficient such as a frozen road surface, the hysteresis loss friction (1) is extremely low, and frictions due to items (2), (3) are predominant.

10 Although a spiked tyre can provide an excellent gripping force on a frozen road surface since it produces a large dig-out friction force, there has recently been a tendency to inhibit the use of spiked tyres so as to prevent public pollution caused by powdery dusts. Studless tyres with no spikes have rapidly prevailed.

15 Since the dig-out frictional force depends on the tread pattern or surface form of the tread, studless tyres have also been devised which improved the dig-out frictional force, for example, by incorporating foamed rubber or organic fibre thereby increasing unevenness on the tread surface. However, the dig-out frictional force of even these studless tyres is low compared to a spiked tyre and, hence, the gripping force thereof is inferior to spiked tyres. Particularly when a frozen road surface is ground smooth by idle rotation of a tyre upon starting a vehicle, the gripping force of the studless tyre is degraded.

20 When on a road surface with an extremely low friction coefficient such as a frozen road surface, the adhesion friction as well as the dig-out friction contributes to an improvement in gripping force. It is important in this instance to increase the area of contact between the road surface and the tyre by eliminating hydroplanes formed by friction thawing the frozen road surface, in order to improve the adhesion friction. The unevenness on the tread surface not only improves the dig-out frictional force but also has the effect of eliminating hydroplaning to increase the adhesion friction.

25 Further, the characteristics of the rubber itself give an effect on the adhesion frictional force. For instance, the adhesion frictional force can be increased by making the rubber material soft thereby increasing the effective area of contact with the road surface.

Although various proposals have been made to improve the gripping force of a studless tyre by increasing the adhesion frictional force, none has been satisfactory and further improvements are demanded.

30 The present invention has been achieved in view of the foregoing technical background and an object thereof is to provide a rubber composition for a tyre tread which provides in a studless tyre an improved gripping force.

35 According to the present invention there is provided a rubber composition for a tyre tread comprising 100 parts by weight of a diene rubber containing as a main component thereof at least one rubber selected from the group consisting of natural rubber, polyisoprene and polybutadiene, and 30 to 90 parts by weight of a vulcanised rubber powder, wherein the vulcanised rubber powder is a powder of a rubber resulting from vulcanisation of a rubber composition including 100 parts by weight of a diene rubber containing as a main component thereof at least one rubber selected from the group consisting of natural rubber, polyisoprene and polybutadiene and 30 to 100 parts by weight of a clay mainly composed of kaolinite.

The present invention will now be described by way of example.

40 At first, explanation is to be made on the rubber composition constituting the vulcanised rubber powder (hereinafter referred to as "rubber composition for powder") used in the tread rubber composition according to the present invention.

The rubber component of the rubber composition for powder includes at least one of natural rubber, polyisoprene rubber and polybutadiene rubber, but may be incorporated with other diene rubber ingredients such as SBR as required.

45 The clay blended with the rubber composition for powder is a clay mainly composed of kaolinite, for which amorphous metakaolin calcined at a high temperature of about 600°C is preferably used.

50 The blending amount of clay in the rubber composition for powder is from 30 to 100 parts by weight, preferably, 40 to 70 parts by weight relative to 100 parts by weight of the rubber component of the rubber composition for powder. If it is less than 30 parts by weight, the effect of increasing the frictional force on a frozen road surface is scarcely observed and, if it exceeds 100 parts by weight, the hardness of the vulcanised rubber powder is increased excessively, resulting in a tendency to reduce the frictional force and fracture resistance of the tread rubber.

55 The clay (generally of about 1.0µm in grain size) blended in the rubber composition for powder has a large grain size and poor reinforcing property as compared with a fine particulate reinforcing material such as carbon black or silica (generally of about 10 to 40µm in grain size). Accordingly, it is preferred to blend a reinforcing material such as carbon black or silica in the rubber composition for powder for providing a reinforcing effect. Among reinforcing agents, it is preferred to blend a silane coupling agent represented by  $X_3SiR$  in which X represents an alkoxy group or chlorine atom and R represents a glycidoxo, methacryl, amino, mercapto, epoxy

or imide group, or  $(\text{C}_n\text{H}_{2n+1}\text{O})_3\text{-Si-(CH}_2)_m\text{-S}_k\text{-(CH}_2)_m\text{-Si-(C}_n\text{H}_{2n+1}\text{O})_3$  in which  $n$  is an integer from 1 to 4, and  $m$  and  $k$  are each an integer from 1 to 6 in an amount from 1 to 8 parts by weight, preferably, 2 to 5 parts by weight relative to 100 parts by weight of the rubber component of the rubber composition for powder. If the blending amount of the silane coupling agent is less than 1 part by weight, the reinforcing effect is scarcely provided, whereas if it exceeds 8 parts by weight, unreacted silane coupling agent is deposited on the surface of the vulcanised rubber powder to rather deteriorate the frictional force undesirably.

Usual additives for rubber blending such as a vulcaniser, a vulcanisation accelerator and, if required, an antioxidant may be blended in the rubber composition for powder.

The rubber composition for powder of such a composition is vulcanised to prepare a clay-incorporated vulcanised rubber which is then powdered to obtain a vulcanised rubber powder. As a powdering method, any known method can be used, including, for example, the freezing pulverisation method.

The grain size of the vulcanised rubber powder is preferably of complete 20 mesh pass and, particularly, of complete 60 mesh pass. If it is greater than the size of complete 20 mesh pass, the resulting fracture resistance is deteriorated.

The rubber component used for the tread rubber composition of the present invention (hereinafter referred to as "matrix rubber component") is a diene rubber comprising at least one of natural rubber, polyisoprene and polybutadiene as the main ingredient, which have a low glass transition temperature and are less curable even at a low temperature. The matrix rubber component comprises at least one of natural rubber, polyisoprene and polybutadiene, but other diene rubber such as SBR may be added as required.

The blending amount of the vulcanised rubber powder in the tread rubber composition is from 30 to 90 parts by weight, preferably, 40 to 70 parts by weight relative to 100 parts by weight of the matrix rubber component. If the blending amount of the vulcanised rubber powder is less than 30 parts by weight, the effect of increasing the frictional force on a frozen road surface is scarcely provided and, if it exceeds 90 parts by weight, the reinforcing property is deteriorated, and the wear resistance, cutting characteristic and the like are unpreferably lowered.

Further, it is preferred that the vulcanised rubber powder is blended such that the blending amount of the clay in the tread rubber composition is from 10 to 40 parts by weight relative to 100 parts by weight of the rubber component of the tread rubber composition (corresponding to the total amount of the matrix rubber component and the rubber component of the vulcanised rubber powder). If it is less than 10 parts by weight, the effect of increasing the frictional force on the frozen road surface is scarcely observed and, if it exceeds 40 parts by weight, the hardness is increased excessively, thus tending to deteriorate the frictional force and the fracture resistance of the tread rubber.

The vulcanised rubber powder may be added after blending other blending ingredients than the rubber powder and homogeneously kneading them, or may be blended together with other blending ingredients and then kneaded homogeneously.

Blending of a specific clay having an effect of increasing the frictional force to form the vulcanised rubber powder to be used in the tread rubber composition is advantageous in suppressing the reduction of the gripping force on a dried road surface and deterioration of the fracture resistance of the tread rubber composition compared with the case of directly blending the clay to the matrix rubber composition, and the amount of the clay to be blended can be readily varied with the performance required.

The present invention will be more specifically described with reference to specific examples thereof. It is to be noted that these examples are only illustrative of the present invention and not limitative thereof.

Firstly to prepare the vulcanised Rubber Composition the rubber compositions for powder were prepared with the formulations shown in Table 1. For the clay, ICECAP K (trade name) manufactured by Shiraishi Calcium Co., Ltd. was used. For the silane coupling agent, KBE1003 (trade name) manufactured by Shin-Etsu Chemical Co., Ltd. was used. This coupling agent is vinyl triethoxysilane. For the vulcanisation accelerator, NOXCELER-NS (trade name) manufactured by Ohuchi Shinko Kagaku Co., Ltd. was used. This is N-tert-butyl-2-benzothiazyl sulfene amide.

Each of the rubber compositions thus prepared was kneaded for about 3 to 10 min by using, for example, a kneader or Banbury mixer and then vulcanised at approximately 140 to 180°C for 10 to 40 min, followed by being pulverised under freezing at -230 to -180°C. Thus vulcanised rubber powders A to J were obtained.

Table 1

Rubber Composition for Powder	Com. ex	Example										Com. ex
		A	B	C	D	E	F	G	H	I	J	
Natural Rubber	100	100	100	100	100	100	50	100	100	100	100	
Polybutadiene	-	-	-	-	-	-	50	-	-	-	-	
Carbon black N220	-	-	20	-	-	-	-	-	-	-	-	
Clay	20	40	40	60	60	60	60	60	60	90	110	
Silane coupling agent	1	2	2	-	2	2	2	6	10	6	6	
Stearic acid	2	2	2	2	2	2	2	2	2	2	2	
Chinese white	4	4	4	4	4	4	4	4	4	4	4	
Antioxidant	1	1	1	1	1	1	1	1	1	1	1	
Sulfur	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
Vulcanisation accelerator	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	

In Table 1, the vulcanised rubber powders A and J comprising the rubber composition for powder in which the blending amount of the clay is out of the scope of the present invention to provide comparative examples, and the vulcanised rubber powders B to I correspond to examples of the present invention.

The tread rubber compositions of the formulations shown in Table 3 according to Examples 1 - 11 and Comparative Examples 1 - 5 were prepared except for changing the kind and the blending amount of the vulcanised rubber powder and the blending amount of the process oil as shown in Table 2. A vulcanised rubber powder of complete 60 mesh pass was used except for Example 7. The vulcanised rubber powder used in Example 7 was the vulcanised rubber powder E prepared as above with a grain size of complete 14 mesh pass (indicated by E\* in Table 3). As the process oil, DIANAPROCESS PS32 (trade name) manufactured by Idemitsu Kosan Co., Ltd. was used. As the antioxidant 6PPD, OZONONE 6C (trade name) manufactured by Seiko Kagaku Co., Ltd. was used.

This is N-phenyl-N'-(1,3-dimethylbutyl)-p-phenylenediamine. For the vulcanisation accelerator, NOXCEL-ER NS (trade name) manufactured by Ohuchi Shinko Kagaku was used. This is N-tert-butyl-2-benzothiazyl sulfene amide.

Table 2

Ingredients	Weight parts
Natural rubber	50
Polybutadiene	50
Carbon black N220	45
Process oil	varied
Vulcanised rubber powder	varied
Stearic acid	2
Chinese white	4
Antioxidant 6PPD	1
Sulfur	1.5
Vulcanisation accelerator	1

In Table 3, the proportion of clay to tread rubber composition is the amount of clay (parts by weight) essentially contained in each tread rubber composition and is calculated from the kind and content of vulcanised rubber powder. Taking Example 1, for instance, 50 parts by weight of vulcanised rubber powder B (40 parts by weight of clay is contained in the tread rubber composition ( $100 + 40 + 2 + 2 + 4 + 1 + 1.5 + 0.5 = 151$  parts by weight) and, hence, the proportion of clay to the tread rubber composition is  $50 \times (40/151) = 13$  parts by weight (by counting fractions of 0.5 and over as a unit and cutting away the rest). The proportion of clay to the total amount of rubber components (phr) is the content of clay relative to 100 parts by weight of the total amount of the rubber components in each tread rubber composition (the sum of the matrix rubber component and the rubber component of the vulcanised rubber powder). Taking Example 1, for instance, the total amount of the rubber components of the tread rubber composition is the sum of the content of the rubber component in the vulcanised rubber powder contained in the tread rubber composition and the content of the matrix rubber component, i.e.,  $50 \times (100/155) = 33$  parts by weight (counting fractions of 0.5 and over as a unit and cutting away the rest) + 100 parts by weight = 133 parts by weight. Hence, the proportion of clay to the total amount of the rubber components in the tread rubber composition is  $13 \times (100/133) = 10$  parts by weight (counting fractions of 0.5 and over as a unit and cutting away the rest).

The gripping force and fracture resistance of each of the tread rubber compositions according to Examples and Comparative Examples were evaluated by the following methods, and the results were as shown in Table 3.

#### (1) Gripping Force

Studless tyres size 165R13 were manufactured using each tread rubber composition. These were mounted on a Japanese FF-ABS automobile of 1500 cc, inflated to 2kgf and evaluated by measuring the brake stopping distance on ice at an atmospheric temperature of -3°C and ice temperature of -2.5°C. The brake stopping distance was measured as the distance required to stopping after the wheels were locked when running at a speed of 30 km/h. The measured brake stopping distances are indicated each as an index based on the value measured with Comparative Example 5 not blended with the vulcanised rubber

powder being set at 100.

(2) Fracture Resistance

Vulcanised rubber test pieces were prepared of the respective tread rubber compositions, and evaluated by measuring the tearing strength of the test pieces. The tearing strength was measured according to JIS K6301 and indicated as an index based on the result of Comparative Example 5 not using vulcanised rubber powder being assumed as 100. As the index is larger, the evaluation is better.

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Table 3

		Example											Comparative Example				
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5
Vulcanised rubber powder	Type	B	C	D	E	E	E	E	F	G	H	I	A	E	E	J	-
	Content	50	50	50	50	30	80	50	50	50	50	50	50	20	100	50	-
Process oil		3	5	3	5	3	7	5	5	7	9	9	-	3	9	10	-
Proportion of clay to the total amount of rubber components (phr)		10	9	14	14	9	19	14	14	14	13	18	6	6	22	20	-
Evaluation	Fracture resistance	98	101	104	100	105	99	95	103	98	96	97	106	104	90	93	100
	Braking performance	109	104	103	118	109	111	108	110	106	105	110	98	96	93	95	100

As can be seen from Table 3, all the tread rubber compositions according to the examples of the present invention were better than over the tread rubber compositions according to the comparative examples in terms of the braking performance.

In terms of the fracture resistance, on the other hand, the difference remained within  $\pm 5\%$  even after blending the vulcanised rubber powder, which was not particularly poor as compared with the case of not blending the vulcanised rubber powder. However, the tread rubber composition of Example 7 in which the vulcanised rubber powder with a grain size over 20 mesh tended to show some degradation in the fracture resistance. From Examples 4-6 and Comparative Examples 2 and 3, it can be seen that the fracture resistance tends to be lowered as the blending amount of the same kind of vulcanised rubber powder is increased.

## Claims

1. A rubber composition for a tyre tread, characterised by comprising 100 parts by weight of a diene rubber containing as a main component thereof at least one rubber selected from the group consisting of natural rubber, polyisoprene and polybutadiene, and 30 to 90 parts by weight of a vulcanised rubber powder, wherein the vulcanised rubber powder is a powder of a rubber resulting from vulcanisation of a rubber composition including 100 parts by weight of a diene rubber containing as a main component thereof at least one rubber selected from the group consisting of natural rubber, polyisoprene and polybutadiene and 30 to 100 parts by weight of a clay mainly composed of kaolinite.
2. A rubber composition according to claim 1, characterised in that the vulcanised rubber powder includes 40 to 70 parts by weight of clay mainly composed of kaolinite.
3. A rubber composition according to claim 1 or 2, characterised in that the vulcanised rubber powder includes a silane coupling agent represented by  $X_3SiR$  in which X represents an alkoxy group or chlorine atom and R represents a glycidoxy, methacryl, amino, mercapto, epoxy or imide group or by  $C_nH_{2n+1}O)_3-Si-(CH_2)_m-Si-(CH_2)_m-Si-(C_nH_{2n+1}O)_3$  in which n is an integer from 1 to 4, and m and k are each an integer from 1 to 6.
4. A rubber composition according to claim 1 or 2, characterised in that the vulcanised rubber powder includes a silane coupling agent comprising vinylmethoxysilane.
5. A rubber composition for a tyre tread according to claim 3 or 4, characterised in that said silane coupling agent is blended in an amount of 1 to 8 parts by weight relative to 100 parts by weight of the rubber component of the vulcanised rubber.
6. A rubber composition for a tyre tread according to claim 3 or 4, characterised in that said silane coupling agent is blended in an amount of 2 to 5 parts by weight relative to 100 parts by weight of the rubber component of the vulcanised rubber powder.
7. A rubber composition for a tyre tread as set forth in any one of claims 1 to 6, characterised in that said clay is an amorphous metakaolin calcined at about 600°C.
8. A rubber composition according to any of claims 1 to 7, characterised in that the vulcanised rubber powder has a grain size of complete 20 mesh pass.
9. A rubber composition according to any of claims 1 to 8, characterised in that the vulcanised rubber powder has a grain size of complete 60 mesh pass.
10. A rubber composition according to any of claims 1 to 9, characterised by including 40-70 parts by weight of vulcanised rubber powder.
11. A rubber composition according to any of claims 1 to 11, characterised in that said clay is contained in an amount of 10 to 40 parts by weight relative to 100 parts by weight of the total amount of the rubber components of the rubber composition for tyre tread.
12. A tyre tread comprising a rubber composition according to any one of claims 1 to 11.



13. A tyre comprising a tyre tread formed of a rubber composition for tyre tread as recited in any one of claims 1 to 11.

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European Patent  
Office

# EUROPEAN SEARCH REPORT

Application Number  
EP 95 30 2555

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US-A-4 522 970 (R.M.SCRIVER ET AL.) * claim 1 *	1-13	C08K3/34 C08L21/00 B60C1/00
A	EP-A-0 361 667 (THE YOKOHOMA RUBBER CO) * claims 1-3 *	1-13	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			C08K C08L B60C
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 6 July 1995	Examiner Van Humbeeck, F
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 CLASS (P04C01)